PATENT SPECIFICATION 1,053,602

DRAWINGS ATTACHED.

1,053,602

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COMPLETE SPECIFICATION.

Improvements in and relating to Hydraulic Pumps and Motors.

I, HANS THOMA, a German Citizen of Bellevueweg 25, Zug, Switzerland, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to axial piston hydraulic pumps or motors of the type comprising a rotary cylinder block formed with a number of axial or substantially axial cylinder bores housing pistons which co-operate with an inclined or inclinable drive member, a non-rotary valve member having ports which co-operate with ports in the cylinder block to control the admission and discharge of fluid from the cylinder bores, and hydraulic balancing means acting to urge the cylinder block towards the valve member.

Thus for example the invention may be applied both to so-called "tilting head" pumps or motors, and also to pumps or motors of the type in which the drive member is a non-rotary cam member.

Broadly the present invention consists in an axial piston hydraulic pump or motor of the type specified in which the hydraulic pump or motor comprises a rotary cylinder block formed with a number of axial or substantially axial cylinder bores housing pistons which co-operate with an inclined or inclinable drive member, a non-rotary valve member having ports which co-operate with ports in the cylinder block to control the admission and discharge of fluid from the cylinder bores, and hydraulic balancing means acting to urge the cylinder block towards the valve member, the hydraulic balancing means comprises a hydraulic thrust generator including a piston and cylinder assembly to which hydraulic fluid is admitted under pressure, the thrust generator being located within a non-rotary part of the apparatus, and connected by way of a rotary thrust bearing to a rotary shaft which is connected to the rotary cylinder block so as to transmit the axial thrust of the generator to the cylinder block.

In a hydraulic pump or motor according to a preferred form of the present invention the rotary shaft extends axially through the cylinder block and engages said block at or near the end remote from the valve member through a universal pivotal joint so as to permit the block to have freedom to tilt and align itself in relation to the opposing face of the valve plate.

In a hydraulic pump or motor according to one embodiment of the present invention the hydraulic thrust generator is located in or on the valve member and comprises a cylinder containing a single annular piston which is urged axially outwards by pressure liquid which enters the cylinder on the underside of the annular piston through passages containing each a non-return valve leading from the usual inlet and discharge ports within the valve member.

The axial force acting on the annular balancing piston is imparted to the outer end of the rotary shaft, through a plain thrust bearing. The rotary shaft extends axially through clearance holes in the valve member and the cylinder block and engages the end of the cylinder block remote from the valve member through a hemi-spherical bearing.

By this means the thrust on the balancing piston acts through the aforesaid rotary shaft in tension to pull the cylinder block into firm sealing contact with the co-acting face of the valve member.

In a modified form of the invention the

[*Price 4s. 6d.*]

single annular balancing piston is replaced by two or more pistons or plungers positioned around the axis of the shaft and engaging a thrust plate on the shaft through sliding slippers.

Each of the aforesaid pistons or plungers may be urged axially as in the first embodiment, by a combination of a spring and hydraulic pressure.

In a still further embodiment the one or more balancing pistons or plungers and their cylinder or cylinders are situated in a stationary member at the end of the pump or motor casing opposite to that at which the valve member is situated.

In this embodiment the thrust of the balancing pistons or plungers acts through the rotary shaft in compression to thrust the cylinder block towards the valve member.

In some cases the rotary shaft may extend through the valve member and be used as a drive shaft for the cylinder block. Alternatively the two shafts may be separate. The connection between the rotary shaft and the cylinder block is preferably such as to permit the shaft to have freedom for slight longitudinal movement and the cylinder block freedom to tilt relative to the shaft. Alternatively the shaft may be rigidly connected to the cylinder block, and formed with sufficient flexibility to allow the cylinder block to tilt and align itself with the valve member. In this latter case other means, such as a surrounding radial bearing, should be provided to locate the cylinder block radially.

The invention may be performed in various ways and five different designs of a hydraulic pump or motor constituting five embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:—

Figure 1 is a longitudinal section through a hydraulic pump or motor according to one embodiment,

Figure 2 is a view similar to Figure 1 of the second embodiment,

Figure 3 is a view similar to Figure 1 showing parts enclosed in a casing and illustrating the third embodiment,

Figure 4 is a longitudinal section through a hydraulic pump or motor according to the fourth embodiment,

Figure 5 is a longitudinal section through a hydraulic pump or motor according to the fifth embodiment.

The hydraulic pump or motor according to each of the examples illustrated in the drawings comprises basically a rotary cylinder block 1 having a plurality of displacement cylinders lying parallel to the axis of rotation of the block and regularly disposed around this axis, each such cylinder containing a piston 2 provided with connecting rods 4.

In Figure 1, which illustrates a "tilting head" pump the connecting rods 4 are connected to a rotary drive plate 3 through ball and socket joints. The rotary drive plate 3 is driven by a drive shaft 3A, whose axis is inclined or inclinable to the axis of the cylinder block 1, and such drive is imparted simultaneously to the cylinder block in known manner through the action of the pistons 2 and connecting rods 4.

The cylinder block is rotated relatively to a stationary valve member 30 and both the cylinder block and the valve member have flat planar faces which are held firmly in contact with each other to form a seal to prevent the escape of liquid in its flow between the cylinder ports in the cylinder block and the usual kidney shaped recesses and the main passages D1 and D2 in the valve member, all according to known practice.

External means (not shown) are provided for altering the inclination between the bearings supporting the shaft 3A and the casing member supporting the valve member 30, and articulated pressure fluid connections are also associated with the main inlet and outlet passages D1, D2, in the valve member.

The cylinder block and the valve member are held firmly in sealing contact with each other by a hydraulic balancing means, which operates through a longitudinally movable rotary shaft 8 to pull the cylinder block hard against the valve member.

In the embodiment illustrated in Figure 1 the hydraulic balancing means is mounted partly within the valve member 30 and it comprises a hydraulic thrust generator consisting of a single annular piston 11 within a cylinder in the body of the valve member.

This annular piston 11 is urged in an axial outward direction by a spring 25 and by pressure liquid admitted to its underside through passages 21 and 22 leading from the main passages D2 and D1 respectively. Each of the passages 21, 22, includes a non-return valve such that pressure fluid will be delivered to the piston 11 irrespective of the direction of rotation of the pump, or whether it is used as a motor.

The pressure acting on the annular piston 11 is transferred to the shaft 8 through an annular thrust block 14 secured by lock nuts 14A to the outer end of the shaft 8. This produces a slight longitudinal outward movement of the shaft 8 and this movement in turn is transmitted to the underside of the cylinder block 1 which in consequence is pulled upwards in the drawing to hold the flat or plane valve face on the cylinder block in firm contact with the opposing flat

or plane valve face on the valve member 30.

So that the cylinder block shall be self-aligning in relationship to the valve member it is provided with an over-size clearance hole along its axis for the shaft 8 and it is engaged by the shaft through a universal pivotal joint centred on the axis and provided by a hemispherical enlargement 10 on the shaft engaging with a correspondingly shaped seating in the lower end of the cylinder block. By this means the cylinder block has a universal freedom to tilt relatively to the valve member 30 and shaft 8 about the centre of the pivotal joint, which is situated at the end of the cylinder block remote from the valve member.

To permit the rotary drive plate 3 to be angularly adjusted relative to the cylinder block the lower end of the shaft 8 is connected to the rotary thrust plate by means of a footstep bearing in the form of a ball and socket joint 9 which also permits relative axial movement of the shaft 8.

As a consequence of the heavy load and resultant friction at the pivotal bearing 10 the shaft 8 will rotate with the cylinder block, such rotary motion will be imparted also to the thrust block 14. By the use of a stop pin 27 the piston 11 is prevented from rotating, and therefore lubrication is necessary between the piston 11 and the thrust block 14, which in the example illustrated is supplied by oil fed through a small passage 111 from a pressure space within the balancing cylinder.

The single annular balancing piston 11 shown in Figure 1 may be replaced by a number of individual pistons arranged on opposite sides of or around the shaft 8. Such an embodiment is illustrated in Figure 2 wherein two diametrically opposed balancing pistons 11 are shown, both slidably engaging with the underface of a thrust plate 14 mounted on the upper end of and rotating with the shaft 8.

In the illustration two possible forms of piston 11 are shown, that on the left having a sliding slipper 13 mounted on a ball end on the piston and supplied with lubricating oil by an internal passage 12, and that on the right having a connecting rod provided with an extended surface on its upper or outer end for sliding engagement with the thrust plate 14.

Where a plurality of balancing pistons 11 are used disposed at regular intervals around the shaft 8 a single sliding slipper in the form of an annular ring common to the series of pistons 11 may be used instead of separate slippers individual to each piston. Such one or more sliding slippers may be lubricated and supported by an oil film in the usual way fed through passages such as 12. Alternatively, when using a single annular slipper this may be supported by an interposed roller bearing. It will be seen that since the thrust bearing assembly is located at a point remote from the cylinder block, and in a non-rotary part of the machine, it is possible to adopt relatively large dimensions for the thrust bearing without affecting the design or dimensions of the cylinder block.

In the example illustrated in Figure 2 springs 25 are provided behind the pistons 11, and the body 16 containing the balancing cylinders is made separately from the valve member 30 and adapted to fit into a recess in the upper surface thereof and be held therein by bolts or studs. This construction enables oil and pressure distributing grooves 17 and 18 to be cut in the opposing surfaces of the body 16, and the recess in the valve member; the groove 18 being in the bottom face of the recess and fitted with an O-ring 23 or other suitable seal.

The embodiment illustrated in Figure 3 comprises a pump or motor of the type having a non-rotary inclinable cam member 3B co-operating with the pistons 2. In this embodiment the shaft 8 is extended away from the valve member to provide a one piece shaft acting also as a drive shaft 3A for the cylinder block. To this end the shaft 8 in the region of the hemi-spherical portion 10, is provided with splines or spur teeth 40 to co-operate with internal teeth 41 on the cylinder block and form a driving connection between the shaft 8 and the cylinder block. It will be noted that the splines or teeth 40, 41, are comparatively short in an axial direction, and that a plane perpendicular to the length of the shaft 8 and passing through the centre of the hemispherical portion 10 intersects this spline conpling at approximately the mid-point of its axial length. The surface 10 is accordingly somewhat cut back at its periphery as compared with the constructions of Figures 1 and 2.

If desired the shaft 8 may be separate from the driving portion 3A as in the examples shown in Figures 1 and 2, the shaft 8 proper then ending at a point above the toothed connection 40, 41.

In other respects the embodiment illustrated in Figure 3 is approximately the same as that shown in Figure 2.

In Figure 4 is illustrated an embodiment similar to that illustrated in Figure 3 but differing therefrom in that the hydraulic balancing means is disposed in a casing which is attached to the end of the pump or motor casing remote from the valve member 30. In this embodiment the balancing pistons 11, of which there may be one or more as preferred, are arranged to be urged in an upward direction against the thrust

plate 14 on the lower end of the shaft 8, so as to cause said shaft to push the pump or motor cylinder block 1 up against the underface of the valve member 30.

In this embodiment also the shaft 8 forms the drive shaft for the cylinder block, but the driving or power input end of the shaft is at the top where it extends through and beyond the valve member 30, and said shaft is permitted to be free to move longitudinally within limits and to this end it is supported at opposite ends by radial bearings 42 and 43 which permit the shaft to slide axially therein.

In this embodiment pressure liquid from the passages D1 and D2 in the valve member 30 is fed to the inlets 21 and 22 of the balancing cylinders through piping, not shown.

In Figure 5 is illustrated a "tilting head" type of pump in which the rotary shaft 8 is separate from the drive shaft 3A but connected thereto through a universal coupling such as the cardan type joint 32.

This embodiment includes a hydraulic balancing thrust generator comprising a single annular piston 11 and cylinder assembly of modified form in that it has three stepped portions each of a different diameter, with the portion of smaller diameter at the lower or inner end, and the portion of largest diameter at the outer end. In other essential respects the design of the hydraulic thrust generator is similar to that illustrated in Figure 1 of the drawings.

It is an essential of the present invention that the hydraulic balancing means shall be mounted on a stationary part of the pump or motor so as to be non-rotating when said pump or motor is operating and that the thrust created by the pressure liquid acting on its one or more pistons or plunger shall be imparted to the shaft 8 through a thrust bearing device such as a thrust plate mounted on and attached to said shaft 8 whereby the shaft 8 is free to rotate relative to said one or more balancing pistons or plungers.

In order to assist in obtaining a proper balance of forces on the cylinder block, and to reduce tilting moments exerted thereon by the hydraulic fluid, it is preferred that the cylinder ports in the cylindrical block should be offset inwards towards the axis of rotation of the cylinder block relative to the cylinder bores in the block.

It is also preferred to embody the improvements in a hydraulic pump or motor in which the co-acting sealing faces of the valve plate and cylinder block are flat and planar and not curved.

It will be noted that in all the described embodiments the piston and cylinder components of the hydraulic thrust generator are not subject to relative rotation. Thus wear is reduced, and effective sealing devices such as O-rings can be used.

WHAT I CLAIM IS:—

1. An axial piston hydraulic pump or motor comprising a rotary cylinder block foromed with a number of axial or substantially axial cylinder bores housing pistons which co-operate with an inclined or inclinable drive member, a non-rotary valve member having ports which co-operate with ports in the cylinder block to control the admission and discharge of fluid from the cylinder bores, and hydraulic balancing means acting to urge the cylinder block towards the valve member, the hydraulic balancing means comprising a hydraulic thrust generator including a piston and cylinder assembly to which hydraulic fluid is admitted under pressure, the thrust generator being located within a non-rotary part of the apparatus, and connected by way of a rotary thrust bearing to a rotary shaft which is connected to the rotary cylinder block so as to transmit the axial thrust of the generator to the cylinder block.

2. A hydraulic pump or motor according to claim 1, in which the shaft extends axially through the centre of the cylinder block and engages said cylinder block at a point spaced from the valve member, the arrangement being such that the cylinder block has freedom to tilt so as to be self-aligning in relation to the valve member.

3. A hydraulic pump or motor according to claim 1 or claim 2, in which the rotary shaft is connected to the cylinder block so as to rotate therewith.

4. A hydraulic pump or motor according to claim 1 or claim 2 or claim 3, in which the rotary shaft is connected to the cylinder block by a joint capable of allowing limited pivotal movements of the cylinder block relative to the shaft.

5. A hydraulic pump or motor according to claim 4, in which the joint comprises two part-spherical surfaces centred at a point on the axis of the cylinder block remote from the valve member.

6. A hydraulic pump or motor according to claim 5, including a toothed or splined coupling interconnecting the shaft and the cylinder block and situated adjacent a plane perpendicular to the shaft and passing through the centre of the part-spherical surfaces.

7. A hydraulic pump or motor according to claims 1, 2, or 3, in which the shaft is rigidly secured to the cylinder block so that the two are relatively immovable and said shaft is sufficiently flexible as to permit the cylinder block to be self-aligning in relation to the valve member.

8. A hydraulic pump or motor according to any of the preceding claims, in which

the hydraulic thrust generator is carried by and situated in the valve member.

9. A hydraulic pump or motor according to any of the preceding claims 1 to 7, in which the hydraulic thrust generator is carried by a stationary member that is situated at the end of the pump or motor which is opposite to that at which the valve member is situated.

10. A hydraulic pump or motor according to any of the preceding claims, in which the hydraulic thrust generator comprises an annular piston and cylinder assembly surrounding the axis of the cylinder block.

11. A hydraulic pump or motor according to any of the preceding claims 1 to 9, in which the hydraulic thrust generator comprises a number of individual piston and cylinder assemblies, spaced around the axis of the cylinder block.

12. A hydraulic pump or motor according to any of the preceding claims, in which the rotary thrust bearing between the hydraulic thrust generator and the rotary shaft comprises co-operating annular surfaces surrounding the axis of the cylinder block.

13. A hydraulic pump or motor according to any of the preceding claims, in which the hydraulic thrust generator is connected to the pressure liquid discharge port in the case of a hydraulic pump, or the pressure inlet port in the case of a hydraulic motor.

14. A hydraulic pump or motor according to claim 13, in which the hydraulic thrust generator is connected to both the inlet and discharge ports through passages each containing a one-way valve, so that the thrust generator is supplied with fluid under pressure irrespective of the mode of operation of the pump or motor.

15. A hydraulic pump or motor according to any of the preceding claims, including a drive shaft connected to rotate with the cylinder block, the rotary shaft for transmitting to the cylinder block the axial force created by the hydraulic thrust generator being separate from the said drive shaft.

16. A hydraulic pump or motor according to any of the preceding claims 1 to 15, in which the rotary shaft also acts as a drive shaft for the cylinder block.

17. A hydraulic pump or motor according to any of the preceding claims, in which the sealing surfaces on the cylinder block and the co-acting sealing surfaces on the valve member are flat and planar.

18. A hydraulic pump or motor according to any of the preceding claims, in which the ports in the cylinder block are offset inwards towards the axis of rotation of the cylinder block, with respect to the cylinder bores in the block.

19. A hydraulic pump or motor according to any of the examples herein described and illustrated in the accompanying drawings.

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1053602 COMPLETE SPECIFICATION
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Sheet 1

Fig. 1.

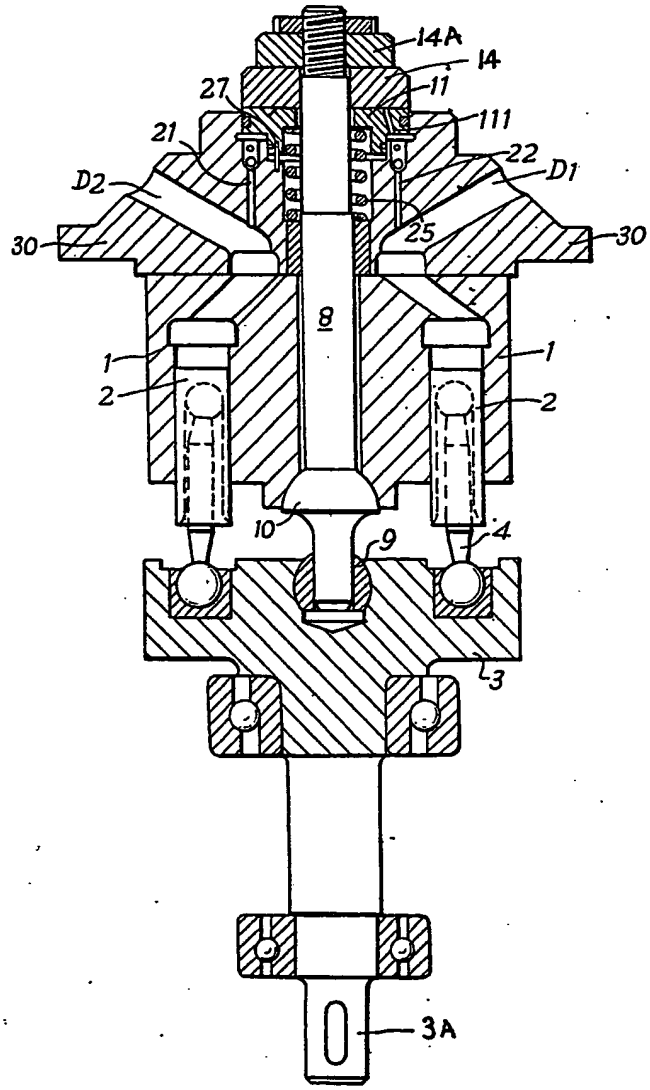
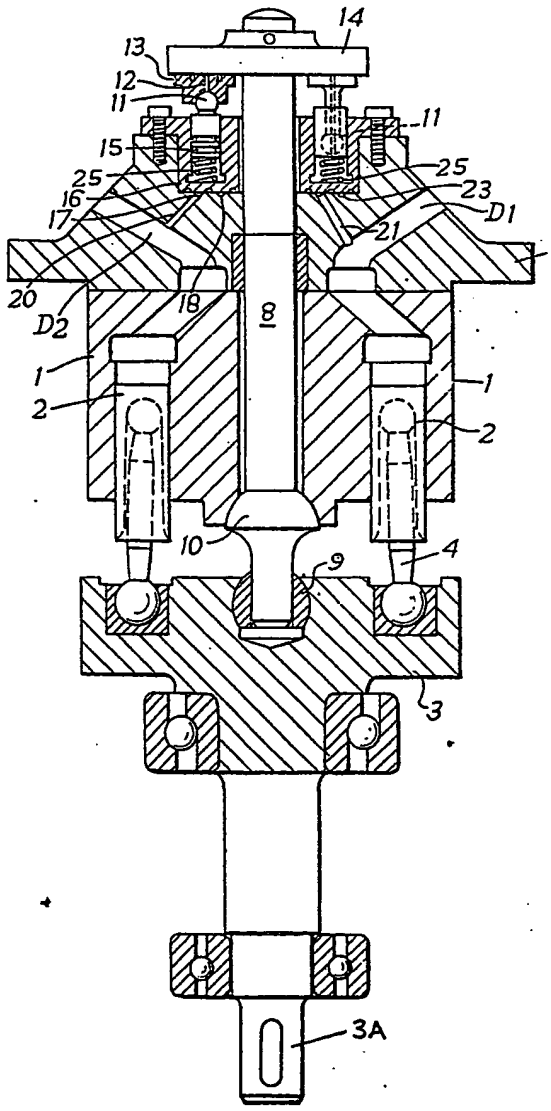


Fig.2.



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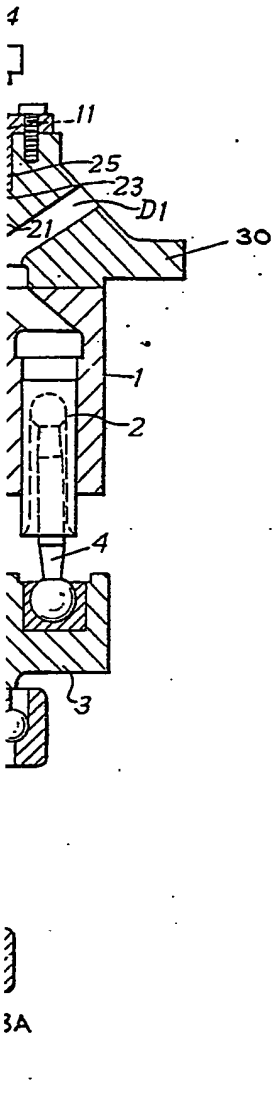
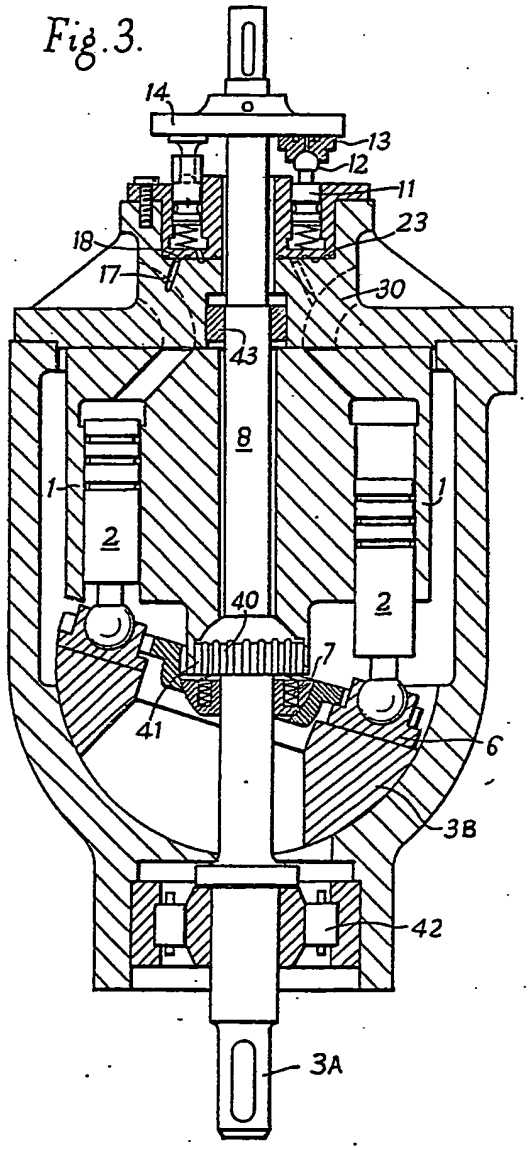


Fig. 3.



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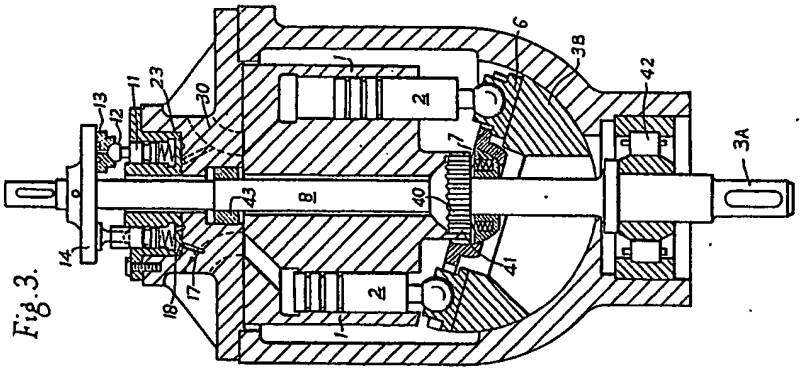

Fig. 3.

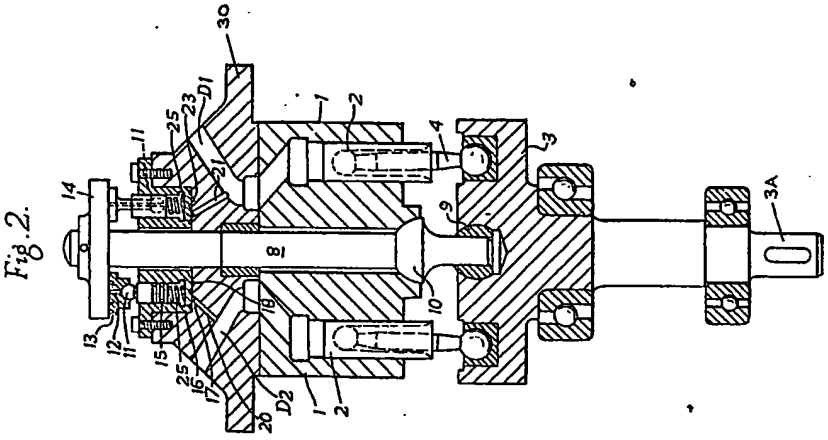

Fig. 2.

Fig.4.

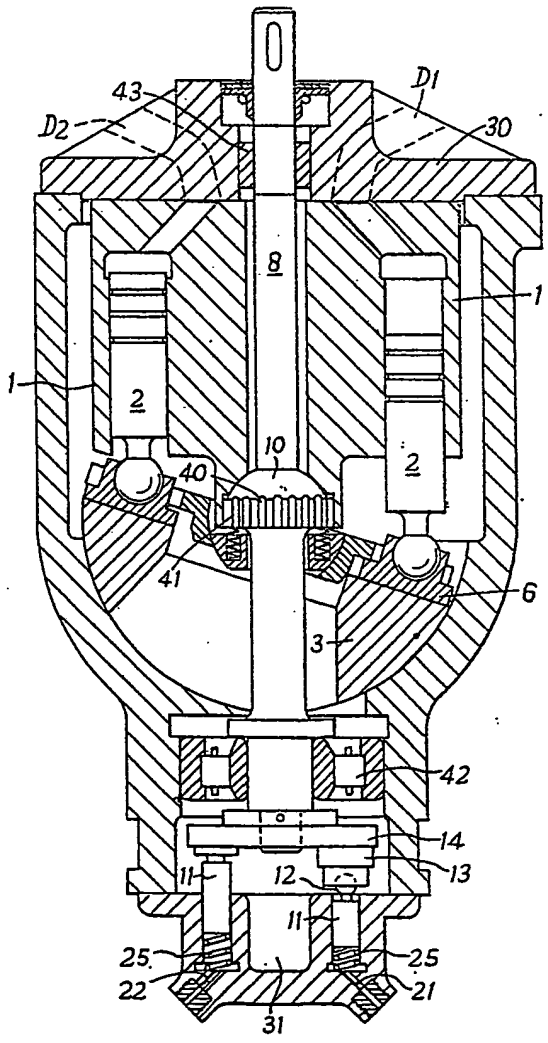

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Fig. 5.

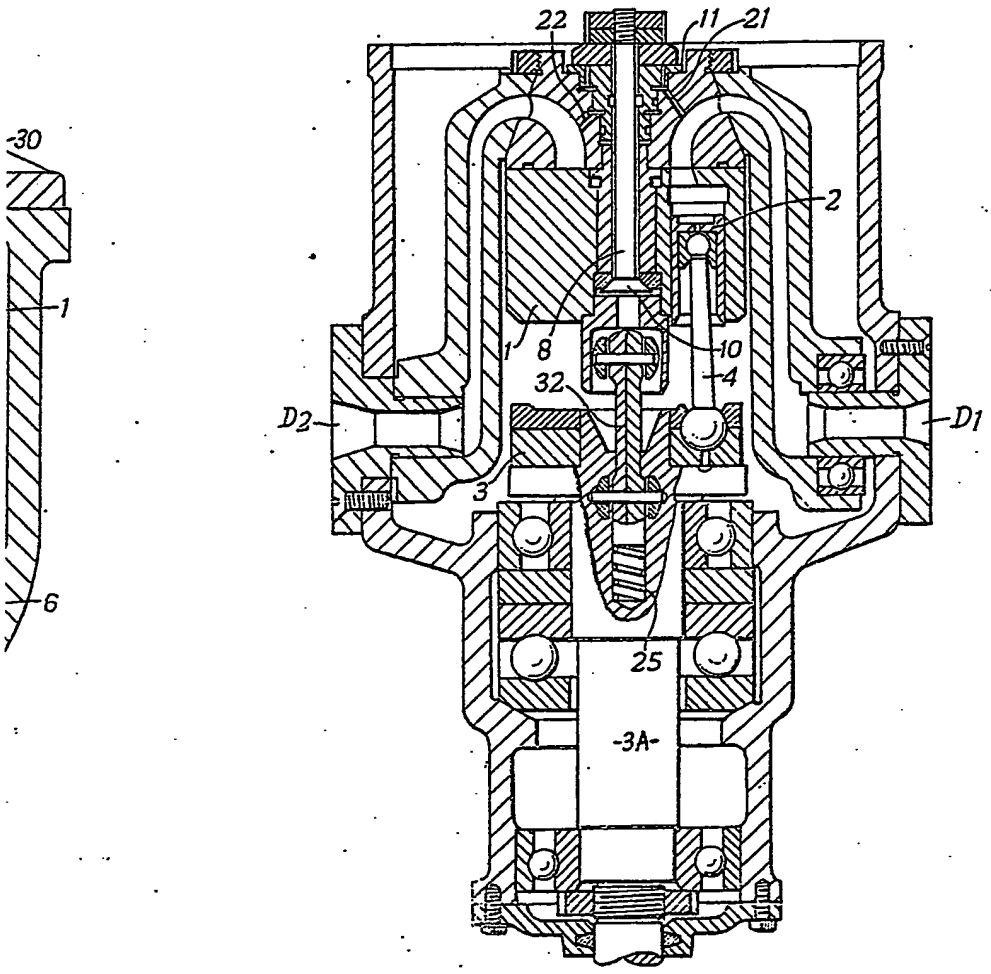

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Fig. 5.

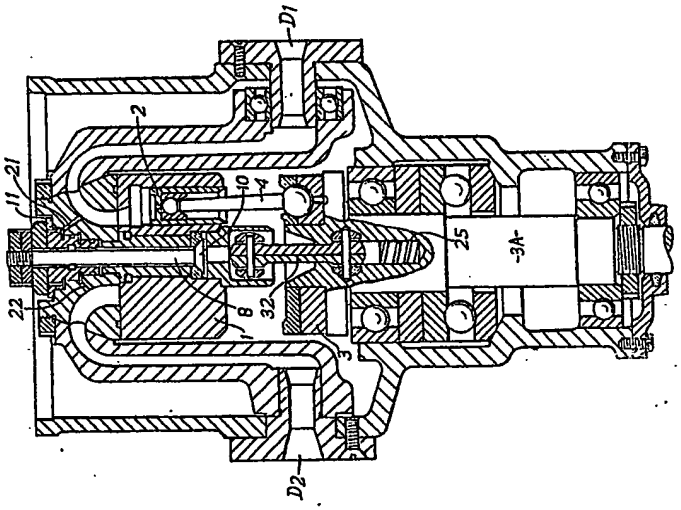

Fig. 4.